

FORM PTO-1390
OFFICE
(REV 11-2000)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK

ATTORNEY'S DOCKET NUMBER

449122009400

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

09/889518
Not yet assigned

**TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. § 371**

INTERNATIONAL APPLICATION NO.

PCT/DE00/00005

INTERNATIONAL FILING DATE

3 January 2000

PRIORITY DATE CLAIMED

19 January 1999

TITLE OF INVENTION

JUL 18 2001

METHOD FOR OBTAINING INFORMATION REGARDING INTERFERENCE
IN THE RECEIVER OF A MESSAGE TRANSMISSION SYSTEM

APPLICANT(S) FOR DO/EO/US

Paul BAIER *et al.*

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☒ is attached hereto (required only if not communicated by the International Bureau).
 - b. ☐ has been communicated by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
- ☒ An English language translation of the International Application under PCT Article 19 (35 U.S.C. 371(c)(2)).
 - a. ☒ is attached hereto.
 - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
- ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
 - a. ☒ are attached hereto (required only if not communicated by the International Bureau).
 - b. ☐ have been communicated by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☐ have not been made and will not be made.
- ☒ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information: 1. IPER; 2. Int'l Search Report; 3. Application Data Sheet; 4. Return receipt postcard.

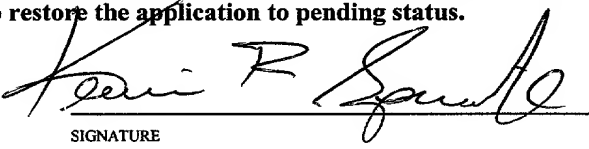
CERTIFICATE OF HAND DELIVERY

I hereby certify that this correspondence is being hand filed with the United States Patent and Trademark Office in Washington, D.C. on July 18, 2001.

R. Lynn Boyden

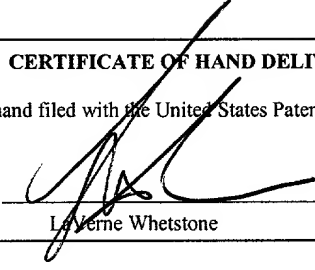
| | | | | | |
|---|--|---|--|---|--|
| U.S. APPLICATION NO. (if known, see 37 CFR 1.5) Not yet assigned | | INTERNATIONAL APPLICATION NO. PCT/DE00/00005 | | ATTORNEY'S DOCKET NUMBER: 449122009400 | |
|---|--|---|--|---|--|

09/889518

| | | | | | | |
|--|--------------|--------------|------------|----------|--------------------------------------|-----|
| 21. <input checked="" type="checkbox"/> The following fees are submitted: BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5)): Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO.....\$1,000.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO.....\$860.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO.....\$710.00 International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provision of PCT Article 33(1)-(4)\$690.00 International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)\$100.00 | | | | | CALCULATIONS PTO USE ONLY | |
| ENTER APPROPRIATE BASIC FEE AMOUNT = | | | | | \$860.00 | |
| Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input checked="" type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)). | | | | | \$130.00 | |
| CLAIMS | NUMBER FILED | NUMBER EXTRA | RATE | | | |
| Total claims | 29 - 20 = | 9 | x \$18.00 | \$162.00 | | |
| Independent claims | 1 - 3 = | 0 | x \$80.00 | \$0 | | |
| MULTIPLE DEPENDENT CLAIM(S) (if applicable) | | | + \$270.00 | \$270.00 | | |
| TOTAL OF ABOVE CALCULATIONS = | | | | | \$1,422 | |
| <input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. | | | | | \$0 | |
| SUBTOTAL = | | | | | \$1,422 | |
| Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)). | | | | | + | \$0 |
| TOTAL NATIONAL FEE = | | | | | \$1,422 | |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property | | | | | + | \$0 |
| TOTAL FEES ENCLOSED = | | | | | \$1,422 | |
| | | | | | Amount to be refunded: | \$ |
| | | | | | charged: | \$ |
| a. <input checked="" type="checkbox"/> Please charge my Deposit Account No. 03-1952 in the amount of \$1,422.00 to cover the above fees. A duplicate copy of this sheet is enclosed. | | | | | | |
| b. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees that may be required, or credit any overpayment to Deposit Account No. 03-1952 . A duplicate copy of this sheet is enclosed. | | | | | | |
| NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status. | | | | | | |
| SEND ALL CORRESPONDENCE TO: Kevin R. Spivak Morrison & Foerster LLP 2000 Pennsylvania Avenue, N.W. Washington, D.C. 20006-1888 | | | | | | |
|  SIGNATURE | | | | | | |
| Kevin R. Spivak <u>Registration No. 43,148</u> | | | | | | |

CERTIFICATE OF HAND DELIVERY

I hereby certify that this correspondence is being hand filed with the United States Patent and Trademark Office in Washington, D.C. on August 27, 2001.


LeVerné Whetstone

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the application of:

Paul BAIER et al.

Serial No.: 09/889,518

Filing Date: July 18, 2001

For: METHOD FOR OBTAINING
INFORMATION ABOUT
INTERFERENCE IN THE RECEIVER
OF A MESSAGE TRANSMISSION
SYSTEM

Examiner: Not yet Assigned

Group Art Unit: Not yet Assigned

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to the examination on the merits, please amend this application as follows:

09/889,518

In the Specification:

Page 1 before the first paragraph, has been amended to include the following insert:

CLAIM FOR PRIORITY

This application claims priority to International Application No. PCT/DE00/00005 which was published in the German language on January 3, 2000.

Page 1 before the first paragraph, please delete the following:

~~Description~~

Page 1, between lines 4 and 5 has been amended to include the following heading:

TECHNICAL FIELD OF THE INVENTION

Paragraph beginning on line 6 of page 1 has been amended as follows:

The invention relates to a method and a device for wireless data transmission, and in particular, to wireless data transmission where information about interference in a message transmission system is obtained in the receiver.

Page 1, between lines 10 and 11 has been amended to include the following heading:

BACKGROUND OF THE INVENTION

Paragraph beginning on line 11 of page 1 has been amended as follows:

In message or data transmission, it is desirable to obtain as uncorrupted a transmission of the user signals as possible, to suppress interference which exists at the same time and in the same frequency band in addition to the wanted signal, and thermal noise, as well as possible in the receivers. To be able to selectively take measures against interference, it is required to know as much as possible about the characteristics of the interference. Apart from the intensity of the

interference, such characteristics are, for example, its spectrum, its correlation properties and the directions of incidence of the interfering signals at the receiver.

Paragraph beginning on line 24 of page 1 has been amended as follows:

In many cases such as, for example, in permanently installed radio transmission links, potential interfering influences by other permanently installed transmitters, which do not emit any user signals from the point of view of the transmission link under consideration, are known. According to the prior art, such interfering influences can be suppressed by simple measures such as directional transmission and reception, a procedure normally used in microwave radio. In many cases, especially in the multi-subscriber systems of mobile communication, such information on the properties of the interference is not known. Accordingly, countermeasures adapted to the interference cannot be easily taken. Assuming interference-limited multi-subscriber systems in which, therefore, the interference is essentially caused by other users of one's own system, the time correlation of the interfering signals is equal to the time correlation of the wanted signals and is thus known as long as interfering signals which are incident from different directions are uncorrelated. Knowledge of the time correlation of the interfering signals can be utilized in the receiver for improving the transmission quality by decorrelating the interference.

Paragraph beginning on line 9 of page 2 has been amended as follows:

TD-CDMA as disclosed in A. Klein, P.W. Baier: Linear unbiased data estimation in mobile radio systems applying CDMA. IEEE Journal on Selected Areas in Communications, Vol. 11, 1993, p. 1058 to 1066, as an example for third-generation mobile radio systems, uses the hybrid FDMA/TDMA/CDMA (frequency/time/code division multiple access) method. The time correlation of the interfering signals can be taken into consideration in the data detection. An example in which no information about the correlation properties of the interference are utilized is the WCDMA (wideband CDMA) disclosed in F. Adachi, K. Ohno, A. Higashi, T. Dohi, Y.

Okumura: Coherent multicode DS-CDMA mobile radio access DS-CDMA mobile radio system, IEICE Transactions on Communications, Vol. E79-B, No. 9, 1996, p. 1316 to 1324 and F.

Adachi, M. Sawahashi: Wideband multi-rate DS-CDMA for next generation mobile communications systems. Proc. IEEE Wireless Communications Conference (WCC'97), Boulder, 1997, p. 57 to 62, air interface concept which is also proposed for third-generation mobile radio systems and which is based on the hybrid FDMA/CDMA multiple access method.

Paragraph beginning on line 20 of page 2 has been amended as follows:

The disadvantageous factor in the transmission methods corresponding to the prior art, is that they do not obtain information on the received interference (or only to a very limited extent).

Hence, they do not use such information to a desirable degree for improving the transmission quality. For example, no directional information at all is obtained with respect to the interference. If multiple-antenna receivers are used, directional patterns could be generated. For example, when using array antennas, which selectively have less gain for those directions from which strong interfering signals arrive at the receiver, the ratio between useful power and interference power at the receiver end is maximized. However, this would require knowledge of the directions of interference which cannot be obtained in the systems according to the prior art.

Paragraph beginning on line 1 of page 3 has been amended as follows:

The system described above of the time correlations of the interference, for example in the case of TD-CDMA, are not about obtaining information about the interference. Rather, using knowledge about the interference is questionable, especially in mobile communication, since the instantaneous characteristics of the interference can greatly deviate from those assumed due to the permanent changing in time of the spatial constellation of the mobile stations which, as a rule, is not predictable.

Paragraph beginning on line 12 of page 3 has been amended as follows:

The prerequisite of uncorrelated interference signals arriving at the receiver from different directions, which has been addressed above, is also not generally met. If the signal of an interference source propagates toward the receiver along a number of paths with different delay, and/or if the interfering signals coming from one interference source have different directions of incidence at the location of the receiver, the aggregate interference signal produced by superposition of the interference signals at the receiving location have different time correlations than the individual interference signals. Thus, they also have different time correlations from those of the user signal which have been assumed.

Page 3, between lines 25 and 26 has been amended to include the following heading:

SUMMARY OF THE INVENTION

In one embodiment of the invention, there is a method for the wireless data transmission using at least one transmitter and at least one receiver, the receiver having one or more receiving antenna. The method includes, for example, utilizing information on received interference signals to improve the quality of transmission of the data transmission, obtaining quantitative information about received user signals from the received signals of one of the antennas by using a first signal processing algorithm, and obtaining quantitative information about the received interference signals from the received signals of one of the antennas and the quantitative information obtained about the received user signals by using a second signal processing algorithm wherein the quantitative information about the received interference signals is used to generate a directional pattern at the transmitter.

In one aspect of the invention, the first signal processing algorithm provides an estimate of the transmitted user data.

In another aspect of the invention, the first signal processing algorithm provides an estimate of the characteristics of the radio channels operating between the transmitters and the receiver.

In still another aspect of the invention, the second signal processing algorithm includes algorithms to reconstruct the user signals received from the receiving antennas by the quantitative information obtained about the signals.

In yet another aspect of the invention, the second signal processing algorithm includes a weighted or unweighted subtraction of the reconstructed received user signals from the total received signals.

In another aspect of the invention, the second signal processing algorithm includes a forming of the spatial covariance matrix of the received interference signals.

In yet another aspect of the invention, the second signal processing algorithm includes a forming of the temporal covariance functions of the received interference signals at each of the antennas.

In still another aspect of the invention, the second signal processing algorithm includes a forming of the total covariance functions of the received interference signals.

In another aspect of the invention, the second signal processing algorithm includes an estimating of the spatial, temporal and/or total covariance functions by finite temporal averaging over the received interference signals.

In still another aspect of the invention, the second signal processing algorithm includes an estimating of the directions of incidence of the interference.

In yet another aspect of the invention, the second signal processing algorithm includes an estimating of the power and/or the spectral shape of the interference.

In another aspect of the invention, the first signal processing algorithm includes a forming of the spatial covariance matrix of the received user signals.

In yet another aspect of the invention, the first signal processing algorithm is based on the principle of a single user detection in the case of data transmission.

In another aspect of the invention, the first signal processing algorithm is based on a principle of multi-user detection in the case of data transmission.

In still another aspect of the invention, the first signal processing algorithm is based on a principle of a rake receiver in the case of data transmission.

In yet another aspect of the invention, the first signal processing algorithm includes forward error correction decoding at the receiver end during data transmission.

In still another aspect of the invention, the first signal processing algorithm is based on a principle of the zero-forcing algorithm.

In yet another aspect of the invention, the first signal processing algorithm is based on a principle of maximum-likelihood estimation or minimum mean square error estimation.

In one embodiment of the invention, there is a system for wireless data transmission. The system includes, for example, a receiver having one or more receiving antennas utilizing information on received interference signals to improve the quality of transmission of the data transmission, wherein quantitative information is obtained about received user signals from the received signals of one of the antennas by using a first signal processing algorithm, and the quantitative information about the received interference signals is obtained from the received signals of one of the antennas and the quantitative information obtained about the received user signals by using a second signal processing algorithm wherein the quantitative information about the received interference signals is used for generating a directional pattern at the transmitter; and a transmitter to generate a directional pattern based on the quantitative information about the received interference signals.

Page 3, between line 25 and line 26 has been amended to include the following:

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 illustrates an exemplary receiving system in the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Paragraph beginning on line 26 or page 3 has been amended as follows:

In one method of the invention, K_a receiving antennas are assumed. In this method, information on the user signal is first obtained from the received signals of the antennas. From the total received signals which contain both the user signal(s) and the interference signal(s), and the information, previously obtained about the user signal(s), information about the interference signal(s) can then be obtained.

Paragraph beginning on line 1 of page 4 has been amended as follows:

In one aspect of the invention, the information about the interference signals is obtained, for example, by an approximate reconstruction of the received user signals and by subsequent subtraction of the reconstructed user signals from the total of the received signals. This embodiment thus provides an estimate of the time functions $\hat{n}^{(ka)}(t)$, $ka = 1..K_a$ of the interference at the K_a receiving antennas.

Paragraph beginning on line 8 of page 4 has been amended as follows:

In another aspect of the invention, the estimates $\hat{n}^{(ka)}(t)$ determined as above, the estimates

$$\hat{R}_n^{(l,m)}(\tau) = E\{\hat{n}^{(l)}(t) \cdot \hat{n}^{(m)}(t + \tau)\} \quad l, m = 1..K_a \quad (1)$$

of the temporal covariance functions of the interference signals effective at the antennas can be obtained. In addition, the normalized spatial covariance matrix

$$\hat{R}_s = \frac{1}{\sigma^2} \begin{pmatrix} E\{\hat{n}^{(1)}(t) \cdot \hat{n}^{(1)}(t) * (t)\} & E\{\hat{n}^{(1)}(t) \cdot \hat{n}^{(K_a)}(t) * (t)\} \\ E\{\hat{n}^{(2)}(t) \cdot \hat{n}^{(1)}(t) * (t)\} & E\{\hat{n}^{(2)}(t) \cdot \hat{n}^{(K_a)}(t) * (t)\} \\ E\{\hat{n}^{(K_a)}(t) \cdot \hat{n}^{(1)}(t) * (t)\} & E\{\hat{n}^{(K_a)}(t) \cdot \hat{n}^{(K_a)}(t) * (t)\} \end{pmatrix} \quad (2)$$

of dimension $K_a \times K_a$ can be determined for the K_a receiving antennas, taking into consideration the interference power σ^2 , which can also be determined from the estimated interference signals. In the case of both the data transmission and digital signal processing at the receiving end, discrete-time samples are available as signals which can be subdivided into finite blocks due to their burst structure. If the subscriber signals are detected burst by burst, it is sufficient to determine information about the interference burst by burst. Accordingly, the interference signals at the individual antennas,

estimated in accordance with the embodiments of the method according to one aspect of the invention, can be represented as vectors

$$\underline{\hat{n}}^{(ka)} = (\hat{n}_1, \hat{n}_2, \dots, \hat{n}_{WB})^T, ka = 1..K_a \quad (3)$$

where \hat{n}_i , $i=1..WB$, are the WB samples of the interference signal over one burst, since these interference signals are time-discrete and limited in time. The embodiment of the method according to one aspect thus leads to finite, discrete-time covariance functions.

Paragraph beginning on line 9 of page 5 has been amended as follows:

Instead of forming the expected value when determining the covariance functions, which requires infinite averaging over the estimated samples of the interference, the temporal averaging is preferably finite in real systems. It is performed over a previously defined number Z of bursts. In the case of a mobile radio system, Z depends on the rate of change of the constellation of mobile stations. If the constellation of mobile stations changes greatly from burst to burst, Z must be selected to be equal to one. If not, Z can be greater than 1. If the Z vectors according to (3) at the K_a antennas according to

$$\hat{\underline{N}}_t^{(ka)} = (\hat{n}_1^{Ka}, \hat{n}_2^{Ka} \dots \hat{n}_Z^{Ka})^T, ka = 1..Ka \quad (4)$$

are ordered into in each case WB x Z matrices, estimates

$$\hat{\underline{R}}_n^{(l,m)} = \frac{1}{Z} \cdot \hat{\underline{N}}_t^{(l)} \cdot \hat{\underline{N}}_t^{(m)*T}, \quad l, m = 1..Ka \quad (5)$$

of the temporal covariance matrices can be formed in derivation of (1). The following then holds for the estimate of the total covariance matrices:

Paragraph beginning on line 34 of page 6 has been amended as follows:

An important advantage, which can be achieved with the method according to the invention, lies in

that, instead of possibly faulty information about the interference to be expected, the information about the interference is obtained from the actual received signal and is thus continuously updated. A further advantage lies in the possibility of obtaining information both on the spatial correlation characteristics of the interference and on the temporal correlation characteristics of the interference.

Paragraph beginning on line 5 of page 7 has been amended as follows:

This information can be used either directly to suppress interference when estimating the user signals from the received signals. Alternatively, information about the directions of incidence of the interference at the receiver can be obtained from the information about the spatial correlation characteristics of the interference, depending on the signal processing algorithm. In the case of multi-antenna receivers, the information about the directions of incidence of the interference at the receiver or, respectively, about the spatial correlation characteristics of the interference can be used for generating directional patterns. The patterns,

of which selectively have less gain in those directions from which strong interference signals arrive at the receiver, cause the ratio between useful power and interference power at the receiver end to be maximized.

Paragraph beginning on line 5 of page 7 has been amended as follows:

The previous considerations relate to the receiver end. In duplex systems, each receiver is paired with a transmitter. If multi-antenna systems are used for receiving and transmitting, the information about the received interference (obtained in accordance with the method explained above) can be used for advantageously driving the antennas in the transmitting case. The basic idea of this is that sending one's own signals into the directions from which strong interference signals are incident tends to produce strong interference in other receivers. When a number of antennas is used, therefore, the knowledge of the main directions of interference at the receiver end can be generally used, independently of the transmission system considered, to radiate as little power of the transmitted signal as possible in the directions of the main interference source and thus to reduce interference seen throughout the system.

Paragraph beginning on line 11 of page 8 has been amended as follows:

The transmitted bursts include two data blocks and a midamble arranged between them which provides for the channel estimate at the receiver end. In the text which follows, the first data block of a burst will be considered in the description of the data detection. A corresponding observation would apply to the second data block. According to R. Schmalenberger, J.J. Blanz: Multi antenna C/I balancing in the downlink of digital cellular mobile radio systems. Proc. IEEE Vehicular Technology Conference (VTC'97), Phoenix, 1997, p. 607 to 611, a system matrix A can be set up which includes both the $K \times K_a$ channel impulse responses of the K subscribers to the K_a receiving antennas and the type of signal generation at the transmitter end. Together with the total data vector d , which includes the data blocks of the K subscribers, and a total interference vector n , the total received-signal vector e

$$e = Ad + n \quad (12)$$

is obtained. e includes samples of the received signals at all K_a antennas which are based on the first data block of a transmitted burst. Firstly, a channel estimator 1 forms a channel estimate and a common detector 2 performs joint detection of the subscriber signals R . Schmalenberger, J.J. Blanz: Multi antenna C/I balancing in the downlink of digital cellular mobile radio systems. Proc. IEEE Vehicular Technology Conference (VTC'97), Phoenix, 1997, p. 607 to 611, by the generally disturbed received signals e . In TD-CDMA systems, algorithms which can include the knowledge of the entire covariance matrix according to (8) are used for the joint data estimate of subscribers.

Paragraph beginning on line 1 of page 9 has been amended as follows:

One example of such algorithms is the zero-forcing algorithm. In one- or multi-antenna receivers in systems according to the prior art, it is assumed that the temporal covariance matrix R_t can be determined directly from the spectral shape of the transmitted signals. In the text which follows, this covariance matrix is designated by R_t . This matrix R_t is taken into consideration in the data detection, even though the actual temporal correlations of the interference signals at the receiving site may deviate from the assumed temporal correlations due to multi-path propagation of the interference from an interference source.

Paragraph beginning on line 14 of page 9 has been amended as follows:

In the case of multi-antenna receivers in systems according to the prior art, the spatial correlations of the interference are not taken into consideration in the detection of the data and/or in the channel estimate, i.e. the covariance matrix R_s is replaced by the $K_a \times K_a$ unity matrix $I^{(K_a)}$. Thus, there is no optimum data detection in the sense of the zero-forcing algorithm in systems according to the prior art. The method according to the invention can be used for

improving the data estimate and the channel estimate by prior estimating of the covariance matrix R_n of the interference due to the estimating of the received interference at each antenna, as shown in figure 1.

Paragraph beginning on line 14 of page 9 has been amended as follows:

To estimate the interference, a conventional data detection is first performed for a number of received bursts, using the matrix

$$\underline{R}_n = I^{(Ka)} \otimes \underline{\tilde{R}}_t \quad (13)$$

for the covariance matrix R_n according to (8), using the matrix $\underline{\tilde{R}}_t$. This provides an estimate

$$\underline{\hat{d}} = \left(\underline{\hat{A}}^{*T} \underline{R}_n^{-1} \underline{\hat{A}} \right)^{-1} \underline{\hat{A}}^{*T} \underline{R}_n^{-1} \underline{e} \quad (14)$$

of the transmitted data which can be used for the approximate reconstruction of the received signal based on the user signals

$$\underline{\hat{e}}_d = \underline{\hat{A}} \cdot \underline{\hat{d}} \quad (15)$$

by the system matrix $\underline{\hat{A}}$ which includes the information about the estimated $K * Ka$ channel impulse responses. The reconstruction $\underline{\hat{e}}_d$ is performed in a signal reconstructor 5. Units 3 and 4 (FEC decoder and FEC coder) can be arranged between units 2 and 5. Unit 3 performs FEC decoding at the receiver end for the case in which FEC coding is taken into consideration in the signal processing at the transmitter end. In unit 4, a corresponding FEC coding of the estimated data takes place to obtain correct signal reconstruction. Subtracting the reconstructed received signal $\underline{\hat{e}}_d$ according to (15) from the actual received signal \underline{e} according to (12) makes it possible to determine an estimate

$$\underline{\hat{n}} = \underline{e} \cdot \underline{\hat{e}}_d \quad (16)$$

for the total interference factor n according to (7). From the estimates of the interference signals at the individual antennas, which were thus obtained, both the spatial correlation characteristics of the interference, see (11), and the temporal correlation characteristics of the interference, see (5), and thus the covariance matrix $\underline{\hat{R}}_n$ of the interference according to (6) can be estimated in an estimating unit 6.

Paragraph beginning on line 32 of page 10 has been amended as follows:

Taking into consideration the estimated covariance matrix, the signals received at the individual antennas can be subjected both to an improved channel estimate, if such a one is required, and to an improved data estimate R_n according to (13) being replaced by $\underline{\hat{R}}_n$.

Paragraph beginning on line 1 of page 11 has been amended as follows:

The procedure described up to here can be iteratively continued. Assuming that the interference scenario, and thus also the correlation characteristics of the interference, do not or do not significantly change during the provided period of estimating the matrix and in the subsequent period which is provided for estimating new data, the estimated covariance matrix $\underline{\hat{R}}_n$ can be used for estimating new data in order to achieve an improvement in the data estimate.

Please delete lines 1-22 on page 12.

On page 13, line 1, please replace "Patent Claims" with --WHAT IS CLAIMED IS--.

In the Claims:

1. (Amended) A method for the wireless data transmission using at least one transmitter and at least one receiver, the receiver having one or more receiving antennas comprising:

utilizing information on received interference signals to improve the quality of transmission of the data transmission;

obtaining quantitative information about received user signals from the received signals of one of the antennas by using a first signal processing algorithm; and

obtaining quantitative information about the received interference signals from the received signals of one of the antennas and the quantitative information obtained about the received user signals by using a second signal processing algorithm wherein the quantitative information about the received interference signals is used to generate a directional pattern at the transmitter.

2. (Amended) The method as claimed in claim 1, wherein the first signal processing algorithm provides an estimate of the transmitted user data.

3. (Amended) The method as claimed in claim 1, wherein the first signal processing algorithm provides an estimate of the characteristics of the radio channels operating between the transmitters and the receiver.

4. (Amended) The method as claimed in claim 1, wherein the second signal processing algorithm includes algorithms to reconstruct the user signals received from the receiving antennas by the quantitative information obtained about the signals.

5. (Amended) The method as claimed in claim 1, wherein the second signal processing algorithm includes a weighted or unweighted subtraction of the reconstructed received user signals from the total received signals.

Please cancel claims 6 and 7.

8. (Amended) The method as claimed in claim 1, wherein the second signal processing algorithm includes a forming of the spatial covariance matrix of the received interference signals.

9. (Amended) The method as claimed in claim 1, wherein the second signal processing algorithm includes a forming of the temporal covariance functions of the received interference signals at each of the antennas.

10. (Amended) The method as claimed in claim 1, wherein the second signal processing algorithm includes a forming of the total covariance functions of the received interference signals.

11. (Amended) The method as claimed in claim 1, wherein the second signal processing algorithm includes an estimating of the spatial, temporal and/or total covariance functions by finite temporal averaging over the received interference signals.

12. (Amended) The method as claimed in claim 1, wherein the second signal processing algorithm includes an estimating of the directions of incidence of the interference.

13. (Amended) The method as claimed in claim 1, wherein the second signal processing algorithm includes an estimating of the power and/or the spectral shape of the interference.

Please cancel claims 14 and 15.

16. (Amended) The method as claimed in claim 1, wherein the first signal processing algorithm includes a forming of the spatial covariance matrix of the received user signals.

17. (Amended) The method as claimed in claim 1, wherein the first signal processing algorithm is based on the principle of a single user detection in the case of data transmission.

18. (Amended) The method as claimed in claim 1, wherein the first signal processing algorithm is based on a principle of multi-user detection in the case of data transmission.

19. (Amended) The method as claimed in claim 1, wherein the first signal processing algorithm is based on a principle of a rake receiver in the case of data transmission.

20. (Amended) The method as claimed in claim 1, wherein the first signal processing algorithm includes forward error correction decoding at the receiver end during data transmission.

21. (Amended) The method as claimed in claim 1, wherein the first signal processing algorithm is based on a principle of the zero-forcing algorithm.

22. (Amended) The method as claimed in claim 1, wherein the first signal processing algorithm is based on a principle of maximum-likelihood estimation or minimum mean square error estimation.

Please cancel claims 23-26.

27. (New) A system for wireless data transmission, comprising:

a receiver having one or more receiving antennas utilizing information on received interference signals to improve the quality of transmission of the data transmission, wherein quantitative information is obtained about received user signals from the received signals of one of the antennas by using a first signal processing algorithm, and

the quantitative information about the received interference signals is obtained from the received signals of one of the antennas and the quantitative information obtained about the received user signals by using a second signal processing algorithm wherein the quantitative information about the received interference signals is used for generating a directional pattern at the transmitter; and

a transmitter to generate a directional pattern based on the quantitative information about the received interference signals.

Please delete lines 1-9 on page 17.

In the Abstract:

Please replace the Abstract in its entirety with the Abstract attached hereto.

REMARKS

The above amendments to the specification, claims and abstract have been made to place the application in proper U.S. format and to conform with proper grammatical and idiomatic English. None of the amendments herein are made for reasons related to patentability. No new matter has been added.

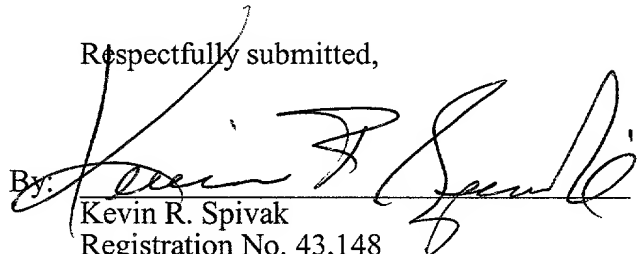
Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "Version with markings to show changes made".

In the unlikely event that the transmittal letter is separated from this document and the Patent Office determines that an extension and/or other relief is required, applicant petitions for any required relief including extensions of time and authorizes the Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to Deposit Account No. 03-1952 referencing docket no. 449122009400. However, the Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

Respectfully submitted,

Dated: August 27, 2001

By:


Kevin R. Spivak
Registration No. 43,148

Morrison & Foerster LLP
2000 Pennsylvania Avenue, N.W.
Washington, D.C. 20006-1888
Telephone: (202) 887-6924
Facsimile: (202) 263-8396

VERSION WITH MARKINGS TO SHOW CHANGES MADE

For the convenience of the Examiner, the changes made are shown below with deleted text in strikethrough and added text in underline.

In the Specification:

Page 1 before the first paragraph, has been amended to include the following insert:

CLAIM FOR PRIORITY

This application claims priority to International Application No. PCT/DE00/00005 which was published in the German language on January 3, 2000.

Page 1 before the first paragraph, please delete the following:

~~Description~~

Page 1, between lines 4 and 5 has been amended to include the following heading:

TECHNICAL FIELD OF THE INVENTION

Paragraph beginning on line 6 of page 1 has been amended as follows:

The invention relates to a method and a device for wireless data transmission, and in particular, to wireless data transmission ~~comprising one or more transmitters and at least one receiver,~~ where information about interference in a message transmission system is obtained in the receiver.

Page 1, between lines 10 and 11 has been amended to include the following heading:

BACKGROUND OF THE INVENTION

Paragraph beginning on line 11 of page 1 has been amended as follows:

In message or data transmission, it is desirable to obtain as uncorrupted a transmission of the user signals as possible, to suppress interference, which exists at the same time and in the same frequency band in addition to the wanted signal, and thermal noise, ~~respectively~~, as well as possible in the receivers. To be able to selectively take measures against interference, it is required to know as much as possible about the characteristics of the interference. Apart from the intensity of the interference, such characteristics are, for example, ~~also~~ its spectrum, its correlation properties and the directions of incidence of the interfering signals at the receiver.

Paragraph beginning on line 24 of page 1 has been amended as follows:

In many cases such as, for example, in permanently installed radio transmission links, potential interfering influences by other permanently installed transmitters, which do not emit any user signals from the point of view of the transmission link under consideration, are known-a ~~priori~~. According to the prior art, such interfering influences can be suppressed by simple measures such as directional transmission and reception,; a procedure normally used in microwave radio. In many cases, especially in the multi-subscriber systems of mobile communication, such information on the properties of the interference is not known-a ~~priori~~. Accordingly, countermeasures adapted to the interference cannot be easily taken. Assuming interference-limited multi-subscriber systems in which, therefore, the interference is essentially caused by other users of one's own system, the time correlation of the interfering signals is equal to the time correlation of the wanted signals and is thus known as long as interfering signals which are incident from different directions are uncorrelated. Knowledge of the time correlation of the interfering signals can be utilized in the receiver for improving the transmission quality by decorrelating the interference.

Paragraph beginning on line 9 of page 2 has been amended as follows:

TD-CDMA as disclosed in A. Klein, P.W. Baier: Linear unbiased data estimation in mobile radio systems applying CDMA. IEEE Journal on Selected Areas in Communications, Vol. 11, 1993, p. 1058 to 1066, as an example for third-generation mobile radio systems, uses the hybrid FDMA/TDMA/CDMA (frequency/time/code division multiple access) method. The time correlation of the interfering signals can be taken into consideration in the data detection. An example in which no information about the correlation properties of the interference are utilized is the WCDMA (wideband CDMA) disclosed in F. Adachi, K. Ohno, A. Higashi, T. Dohi, Y. Okumura: Coherent multicode DS-CDMA mobile radio access DS-CDMA mobile radio system, IEICE Transactions on Communications, Vol. E79-B, No. 9, 1996, p. 1316 to 1324 and F. Adachi, M. Sawahashi: Wideband multi-rate DS-CDMA for next generation mobile communications systems, Proc. IEEE Wireless Communications Conference (WCC'97), Boulder, 1997, p. 57 to 62, air interface concept which is also proposed for third-generation mobile radio systems and which is based on the hybrid FDMA/CDMA multiple access method.

Paragraph beginning on line 20 of page 2 has been amended as follows:

The disadvantageous factor in the transmission methods corresponding to the prior art, is that they do not obtain information on the received interference, (or only to a very limited extent), ~~and thus~~ Hence, they do not use such information to a desirable degree for improving the transmission quality. For example, no directional information at all is obtained with respect to the interference. If multiple-antenna receivers are used, directional patterns could be generated, ~~for~~ For example, when using array antennas, which selectively have less gain for those directions from which strong interfering signals arrive at the receiver, ~~so that~~ the ratio between useful power and interference power at the receiver end is maximized. However, this would require knowledge of the directions of interference which cannot be obtained in the systems according to the prior art.

Paragraph beginning on line 1 of page 3 has been amended as follows:

The ~~considerations~~ system described above of the time correlations of the interference, ~~assumed to be known a-priori~~, for example in the case of TD-CDMA, ~~too~~, are not about obtaining information about the interference. ~~Rather, using~~ Using a-priori knowledge about the interference is questionable, especially in mobile communication, since the instantaneous characteristics of the interference can greatly deviate from those assumed ~~a-priori~~ due to the permanent changing in time of the spatial constellation of the mobile stations which, as a rule, is not predictable.

Paragraph beginning on line 12 of page 3 has been amended as follows:

The prerequisite of uncorrelated interference signals arriving at the receiver from different directions, which has been addressed above, is also not generally met. If the signal of an interference source propagates toward the receiver along a number of paths with different delay, and/or if the interfering signals coming from one interference source have different directions of incidence at the location of the receiver, the aggregate interference signal produced by superposition of the interference signals at the receiving location have different time correlations than the individual interference signals, ~~and thus~~ Thus, they also have different time correlations from ~~than~~ those of the user signal which have been assumed ~~a-priori~~.

Page 3, between lines 25 and 26 has been amended to include the following heading:

SUMMARY OF THE INVENTION

In one embodiment of the invention, there is a method for the wireless data transmission using at least one transmitter and at least one receiver, the receiver having one or more receiving antenna. The method includes, for example, utilizing information on received interference signals to improve the quality of transmission of the data transmission, obtaining quantitative information about received user signals from the received signals of one of the antennas by using a first signal processing algorithm, and obtaining quantitative information about the received

interference signals from the received signals of one of the antennas and the quantitative information obtained about the received user signals by using a second signal processing algorithm wherein the quantitative information about the received interference signals is used to generate a directional pattern at the transmitter.

In one aspect of the invention, the first signal processing algorithm provides an estimate of the transmitted user data.

In another aspect of the invention, the first signal processing algorithm provides an estimate of the characteristics of the radio channels operating between the transmitters and the receiver.

In still another aspect of the invention, the second signal processing algorithm includes algorithms to reconstruct the user signals received from the receiving antennas by the quantitative information obtained about the signals.

In yet another aspect of the invention, the second signal processing algorithm includes a weighted or unweighted subtraction of the reconstructed received user signals from the total received signals.

In another aspect of the invention, the second signal processing algorithm includes a forming of the spatial covariance matrix of the received interference signals.

In yet another aspect of the invention, the second signal processing algorithm includes a forming of the temporal covariance functions of the received interference signals at each of the antennas.

In still another aspect of the invention, the second signal processing algorithm includes a forming of the total covariance functions of the received interference signals.

In another aspect of the invention, the second signal processing algorithm includes an estimating of the spatial, temporal and/or total covariance functions by finite temporal averaging over the received interference signals.

In still another aspect of the invention, the second signal processing algorithm includes an estimating of the directions of incidence of the interference.

In yet another aspect of the invention, the second signal processing algorithm includes an estimating of the power and/or the spectral shape of the interference.

In another aspect of the invention, the first signal processing algorithm includes a forming of the spatial covariance matrix of the received user signals.

In yet another aspect of the invention, the first signal processing algorithm is based on the principle of a single user detection in the case of data transmission.

In another aspect of the invention, the first signal processing algorithm is based on a principle of multi-user detection in the case of data transmission.

In still another aspect of the invention, the first signal processing algorithm is based on a principle of a rake receiver in the case of data transmission.

In yet another aspect of the invention, the first signal processing algorithm includes forward error correction decoding at the receiver end during data transmission.

In still another aspect of the invention, the first signal processing algorithm is based on a principle of the zero-forcing algorithm.

In yet another aspect of the invention, the first signal processing algorithm is based on a principle of maximum-likelihood estimation or minimum mean square error estimation.

In one embodiment of the invention, there is a system for wireless data transmission. The system includes, for example, a receiver having one or more receiving antennas utilizing information on received interference signals to improve the quality of transmission of the data transmission, wherein quantitative information is obtained about received user signals from the received signals of one of the antennas by using a first signal processing algorithm, and the quantitative information about the received interference signals is obtained from the received signals of one of the antennas and the quantitative information obtained about the received user signals by using a second signal processing algorithm wherein the quantitative information about the received interference signals is used for generating a directional pattern at the transmitter; and a transmitter to generate a directional pattern based on the quantitative information about the received interference signals.

Page 3, between line 25 and line 26 has been amended to include the following:

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 illustrates an exemplary receiving system in the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Paragraph beginning on line 26 of page 3 has been amended as follows:

~~The problem of procuring information on the characteristics is solved by the method according to the invention in the manner shown in claim 1.~~ In one method of the invention, where Ka receiving antennas are assumed. In this method, information on the user signal is first obtained from the received signals of the antennas ~~in a first step~~. From the total received signals which contain both the user signal(s) and the interference signal(s), and the information, previously obtained in the first step, about the user signal(s), information about the interference signal(s) can then be obtained ~~in a second step~~.

Paragraph beginning on line 1 of page 4 has been amended as follows:

~~According to the embodiment of the method according to the invention as claimed in subclaims 2, 4 and 5,~~ In one aspect of the invention, the information about the interference signals is obtained, for example, by an approximate reconstruction of the received user signals and by subsequent subtraction of the reconstructed user signals from the total of the received signals. This embodiment thus provides an estimate of the time functions $\hat{n}^{(ka)}(t)$, $ka = 1..Ka$ of the interference at the Ka receiving antennas.

Paragraph beginning on line 8 of page 4 has been amended as follows:

~~Further advantageous embodiments of the method according to the invention are described in subclaims 8, 9 and 10. Using~~ In another aspect of the invention, the estimates $\hat{n}^{(ka)}(t)$ determined as above, the estimates

$$\hat{R}_n^{(l,m)}(\tau) = E\{\hat{n}^{(l)}(t) \cdot (t + \tau)\} \quad l, m = 1..Ka \quad (1)$$

of the temporal covariance functions of the interference signals effective at the antennas can be obtained. In addition, the normalized spatial covariance matrix

$$\hat{R}_s = \frac{1}{\sigma^2} \begin{pmatrix} E\{\hat{n}^{(1)}(t) \cdot \hat{n}^{(1)} * (t)\} & E\{\hat{n}^{(1)}(t) \cdot \hat{n}^{(Ka)} * (t)\} \\ E\{\hat{n}^{(2)}(t) \cdot \hat{n}^{(1)} * (t)\} & E\{\hat{n}^{(2)}(t) \cdot \hat{n}^{(Ka)} * (t)\} \\ E\{\hat{n}^{(Ka)}(t) \cdot \hat{n}^{(1)} * (t)\} & E\{\hat{n}^{(Ka)}(t) \cdot \hat{n}^{(Ka)} * (t)\} \end{pmatrix} \quad (2)$$

of dimension Ka x Ka can be determined for the Ka receiving antennas, taking into consideration the interference power σ^2 , which can also be determined from the estimated interference signals. In the case of both the data transmission and digital signal processing at the receiving end, discrete-time samples are available as signals which can be subdivided into finite blocks due to their burst structure. If the subscriber signals are detected burst by burst, it is sufficient to determine information about the interference burst by burst. Accordingly, the interference signals at the individual antennas,

estimated in accordance with the embodiments of the method according to one aspect of the invention, ~~the invention according to subclaims 2, 4 and 5,~~ can be represented as vectors

$$\hat{n}^{(ka)} = (\hat{n}_1, \hat{n}_2 \dots \hat{n}_{WB})^T, ka = 1..Ka \quad (3)$$

where \hat{n}_i , $i=1..WB$, are the WB samples of the interference signal over one burst, since these interference signals are time-discrete and limited in time. The embodiment of the method according to the invention according to subclaims 8, 9 and 10 one aspect thus leads to finite, discrete-time covariance functions.

Paragraph beginning on line 9 of page 5 has been amended as follows:

Instead of forming the expected value when determining the covariance functions, which requires infinite averaging over the estimated samples of the interference, the temporal averaging ~~must be~~ is preferably finite in real systems. It is performed over a previously defined number Z of bursts. In the case of a mobile radio system, Z depends on the rate of change of the constellation of mobile stations. If the constellation of mobile stations changes greatly from burst to burst, Z must be selected to be equal to one. If not, Z can be greater than 1. If the Z vectors according to (3) at the Ka antennas according to

$$\hat{N}_t^{(ka)} = \left(\hat{n}_1^{Ka}, \hat{n}_2^{Ka} \dots \hat{n}_Z^{Ka} \right)^T, ka = 1..Ka \quad (4)$$

are ordered into in each case WB x Z matrices, estimates

$$\hat{R}_n^{(l,m)} = \frac{1}{Z} \cdot \hat{N}_t^{(l)} \cdot \hat{N}_t^{(m)*T}, \quad l, m = 1..Ka \quad (5)$$

of the temporal covariance matrices can be formed in derivation of (1). The following then holds for the estimate of the total covariance matrices:

Paragraph beginning on line 34 of page 6 has been amended as follows:

An important advantage, which can be achieved with the method according to the invention, lies in

that, instead of possibly faulty a-priori information about the interference to be expected, the information about the interference is obtained from the actual received signal and is thus continuously updated. A further advantage lies in the possibility of obtaining information both on the spatial correlation characteristics of the interference and on the temporal correlation characteristics of the interference.

Paragraph beginning on line 5 of page 7 has been amended as follows:

This information can be used either directly to suppress interference when estimating the user signals from the received signals, ~~or~~ Alternatively, information about the directions of incidence of the interference at the receiver can be obtained from the information about the spatial correlation characteristics of the interference, depending on the signal processing algorithm. In the case of multi-antenna receivers, the information about the directions of incidence of the interference at the receiver or, respectively, about the spatial correlation characteristics of the interference can be used for generating directional patterns. The patterns, ~~of which selectively have less gain in those directions from which strong interference signals arrive at the receiver, cause so that~~ the ratio between useful power and interference power at the receiver end to be is maximized.

Paragraph beginning on line 5 of page 7 has been amended as follows:

The previous considerations relate to the receiver end. In duplex systems, each receiver is paired with a transmitter. If multi-antenna systems are used for receiving and transmitting, the information about the received interference, (obtained in accordance with the method explained above), can be used for advantageously driving the antennas in the transmitting case. The basic idea of this is that sending one's own signals into the directions from which strong interference signals are incident tends to produce strong interference in other receivers. When a number of antennas is used, therefore, the knowledge of the main directions of interference at the receiver end can be generally used, independently of the transmission system considered, to radiate as

little power of the transmitted signal as possible in the directions of the main interference source and thus to reduce interference seen throughout the system.

Paragraph beginning on line 11 of page 8 has been amended as follows:

The transmitted bursts ~~consist of~~ include two data blocks and a midamble arranged between them which provides for the channel estimate at the receiver end. In the text which follows, ~~only~~ the first data block of a burst will be considered in the description of the data detection. A corresponding observation would apply to the second data block. According to R. Schmalenberger, J.J. Blanz: Multi antenna C/I balancing in the downlink of digital cellular mobile radio systems. Proc. IEEE Vehicular Technology Conference (VTC'97), Phoenix, 1997, p. 607 to 611, a system matrix A can be set up which includes both the $K * K_a$ channel impulse responses of the K subscribers to the K_a receiving antennas and the type of signal generation at the transmitter end. Together with the total data vector d, which ~~contains~~ includes the data blocks of the K subscribers, and a total interference vector n, the total received-signal vector e

$$\underline{e} = \underline{A}\underline{d} + \underline{n} \quad (12)$$

is obtained. e ~~contains all~~ includes samples of the received signals at all K_a antennas which are based on the first data block of a transmitted burst. Firstly, a channel estimator 1 forms a channel estimate ~~in a first step~~ and a common detector 2 performs joint detection of the subscriber signals R. Schmalenberger, J.J. Blanz: Multi antenna C/I balancing in the downlink of digital cellular mobile radio systems. Proc. IEEE Vehicular Technology Conference (VTC'97), Phoenix, 1997, p. 607 to 611, by means of the generally disturbed received signals e. In TD-CDMA systems, algorithms which can include the knowledge of the entire covariance matrix according to (8) are used for the joint data estimate of all subscribers.

Paragraph beginning on line 1 of page 9 has been amended as follows:

One example of such algorithms is the zero-forcing algorithm. In one- or multi-antenna receivers in systems according to the prior art, it is assumed that the temporal covariance matrix \underline{R}_t can be determined directly from the spectral shape of the transmitted signals. In the text which follows, this covariance matrix is designated by \underline{R}_t . This matrix \underline{R}_t is taken into consideration in the data detection, even though the actual temporal correlations of the interference signals at the receiving site may deviate from the assumed temporal correlations due to multi-path propagation of the interference from an interference source.

Paragraph beginning on line 14 of page 9 has been amended as follows:

In the case of multi-antenna receivers in systems according to the prior art, the spatial correlations of the interference are not taken into consideration in the detection of the data and/or in the channel estimate, i.e. the covariance matrix \underline{R}_s is replaced by the $K_a \times K_a$ unity matrix $I^{(K_a)}$. Thus, there is no optimum data detection in the sense of the zero-forcing algorithm in systems according to the prior art. The method according to the invention can be used for improving the data estimate and the channel estimate by prior estimating of the covariance matrix \underline{R}_n of the interference due to the estimating of the received interference at each antenna, as shown in see figure 1.

Paragraph beginning on line 14 of page 9 has been amended as follows:

To estimate the interference, a conventional data detection is first performed for a ~~more~~ ~~or less large~~ number of received bursts, using the matrix

$$\underline{R}_n = I^{(K_a)} \otimes \tilde{\underline{R}}, \quad (13)$$

for the covariance matrix \underline{R}_n according to (8), using the matrix $\tilde{\underline{R}}$. This provides an estimate

$$\hat{\underline{d}} = \left(\hat{\underline{A}}^{*T} \underline{R}_n^{-1} \hat{\underline{A}} \right)^{-1} \hat{\underline{A}}^{*T} \underline{R}_n^{-1} \underline{e} \quad (14)$$

of the transmitted data which can be used for the approximate reconstruction of the received signal based on the user signals

$$\hat{\underline{e}}_d = \hat{\underline{A}} \cdot \hat{\underline{d}} \quad (15)$$

by means of the system matrix $\hat{\underline{A}}$ which includes the information about the estimated $K * K_a$ channel impulse responses. The reconstruction $\hat{\underline{e}}_d$ is performed in a signal reconstructor 5. Units 3 and 4 (FEC decoder and FEC coder) can be arranged between units 2 and 5. Unit 3 performs FEC decoding at the receiver end for the case in which FEC coding is taken into consideration in the signal processing at the transmitter end. In unit 4, a corresponding FEC coding of the estimated data ~~must then taken~~ takes place to obtain correct signal reconstruction. Subtracting the reconstructed received signal $\hat{\underline{e}}_d$ according to (15) from the actual received signal \underline{e} according to (12) makes it possible to determine an estimate

$$\hat{\underline{n}} = \underline{e} \cdot \hat{\underline{e}}_d \quad (16)$$

for the total interference factor \underline{n} according to (7). From the estimates of the interference signals at the individual antennas, which were thus obtained, both the spatial correlation characteristics of the interference, see (11), and the temporal correlation characteristics of the interference, see (5), and thus the covariance matrix $\hat{\underline{R}}_n$ of the interference according to (6) can be estimated in an estimating unit 6.

Paragraph beginning on line 32 of page 10 has been amended as follows:

Taking into consideration the estimated covariance matrix, the signals received at the individual antennas can be subjected both to an improved channel estimate, if such a one is

required, and to an improved data estimate, ~~in a second step~~, \underline{R}_n according to (13) being replaced by $\hat{\underline{R}}_n$.

Paragraph beginning on line 1 of page 11 has been amended as follows:

The procedure described up to here can be iteratively continued. Assuming that the interference scenario, and thus also the correlation characteristics of the interference, do not or do not significantly change during the provided period of estimating the matrix and in the subsequent period which is provided for estimating new data, the estimated covariance matrix $\hat{\underline{R}}_n$ can be used for estimating new data in order to achieve an improvement in the data estimate ~~already in the first step~~.

Paragraph beginning on line 1 of page 12 has been amended as follows:

References

- [1] — A. Klein, P.W. Baier: Linear unbiased data estimation in mobile radio systems applying CDMA. IEEE Journal on Selected Areas in Communications, Vol. 11, 1993, p. 1058 to 1066
- [2] — F. Adachi, K. Ohno, A. Higashi, T. Dohi, Y. Okumura: Coherent multicode DS-CDMA mobile radio access DS-CDMA mobile radio system, IEICE Transactions on Communications, Vol. E79-B, No. 9, 1996, p. 1316 to 1324
- [3] — F. Adachi, M. Sawahashi: Wideband multi-rate DS-CDMA for next generation mobile communications systems. Proc. IEEE Wireless Communications Conference (WCC'97), Boulder, 1997, p. 57 to 62

[4]—R. Schmalenberger, J.J. Blanz: Multi antenna C/I balancing in the downlink of digital cellular mobile radio systems. Proc. IEEE Vehicular Technology Conference (VTC'97), Phoenix, 1997, p. 607 to 611

On page 13, line 1, please replace "Patent Claims" with --WHAT IS CLAIMED IS--.

In the Claims:

1. (Amended) A method for the wireless data transmission using at least one or more transmitters and at least one receiver, the receiver having one or more receiving antennas comprising: in which

———~~the receiver uses one or more receiving antennas,~~

utilizing information on received interference signals ~~is utilized for improving to~~ improve the quality of transmission of the data transmission;:

———~~in a first step,~~ obtaining quantitative information about received user signals is ~~obtained~~ from the received signals of one of the ~~individual~~ antennas by using a first signal processing algorithms; and

———~~and in a second step,~~ obtaining quantitative information about the received interference signals ~~is obtained~~ from the received signals of one of the antennas ~~or the individual antennas~~ and the quantitative information obtained about the received user signals by using a second signal processing algorithms wherein the quantitative information about the received interference signals is used to generate a directional pattern at the transmitter.

2. (Amended) The method as claimed in claim 1, ~~characterized in that~~ wherein the first signal processing algorithms provides ~~for~~ an estimate of the transmitted user data.

3. (Amended) The method as claimed in claim 1, ~~characterized in that~~ wherein the first signal processing algorithms provides ~~for~~ an estimate of the characteristics of the radio channels operating between the transmitters and the receiver.

4. (Amended) The method as claimed in claim 1, wherein ~~one of the preceding claims,~~ ~~characterized in that~~ the second signal processing algorithms includes ~~contain~~ algorithms ~~for to~~ reconstructing the user signals received from ~~the receiving antenna~~ the receiving antennas by ~~means of~~ the quantitative information obtained about these signals.

5. (Amended) The method as claimed in claim 1, wherein ~~or 3,~~ ~~characterized in that~~ the second signal processing algorithms includes ~~contain~~ a weighted or unweighted subtraction of the reconstructed received user signals from the total received signals.

Please cancel claims 6 and 7.

8. (Amended) The method as claimed in claim 1, wherein ~~one of the preceding claims,~~ ~~characterized in that~~ the second signal processing algorithms includes ~~contain~~ a forming of the spatial covariance matrix of the received interference signals.

9. (Amended) The method as claimed in claim 1, wherein ~~one of the preceding claims,~~ ~~characterized in that~~ the second signal processing algorithms includes ~~contain~~ a forming of the temporal covariance functions of the received interference signals at each of the individual antennas.

10. (Amended) The method as claimed in claim 1, wherein ~~one of the preceding claims,~~ ~~characterized in that~~ the second signal processing algorithms includes ~~contain~~ a forming of the total covariance functions of the received interference signals.

11. (Amended) The method as claimed in claim 1, wherein one of the preceding claims,
~~characterized in that~~ the second signal processing algorithms includes ~~contain~~ the an estimating
of the spatial, temporal and/or total covariance functions by finite temporal averaging over the
received interference signals.

12. (Amended) The method as claimed in claim 1, wherein one of the preceding claims,
~~characterized in that~~ the second signal processing algorithms includes ~~contain~~ the an estimating
of the directions of incidence of the interference.

13. (Amended) The method as claimed in claim 1, wherein one of the preceding claims,
~~characterized in that~~ the second signal processing algorithms includes ~~contain~~ the an estimating
of the power and/or the spectral shape of the interference.

Please cancel claims 14 and 15.

16. (Amended) The method as claimed in claim 1, wherein one of the preceding claims,
~~characterized in that~~ the first signal processing algorithms includes ~~contain~~ a the forming of the
spatial covariance matrix of the received user signals.

17. (Amended) The method as claimed in claim 1, wherein one of the preceding claims,
~~characterized in that~~ the first signal processing algorithms ~~are~~ is based on the principle of a single
user detection in the case of data transmission.

18. (Amended) The method as claimed in claim 1, wherein one of the preceding claims,
~~characterized in that~~ the first signal processing algorithms ~~are~~ is based on a the principle of
multi-user detection in the case of data transmission.

19. (Amended) The method as claimed in claim 1, wherein one of the preceding claims,
~~characterized in that the first signal processing algorithms are~~ is based on ~~the a~~ principle of ~~the a~~
rake receiver in the case of data transmission.

20. (Amended) The method as claimed in claim 1, wherein one of the preceding claims,
~~characterized in that the first signal processing algorithms includes~~ FEC (forward error
~~correction)~~ forward error correction decoding at the receiver end ~~in the case of~~ during data
transmission.

21. (Amended) The method as claimed in claim 1, wherein one of the preceding claims,
~~characterized in that the first signal processing algorithms is~~ are based on ~~a the~~ principle of the
zero-forcing algorithm.

22. (Amended) The method as claimed in claim 1, wherein one of the preceding claims,
~~characterized in that the first signal processing algorithms are~~ is based on ~~the a~~ principle of
maximum-likelihood estimation or ~~MMSE~~ (minimum mean square error) estimation.

Please cancel claims 23-26.

27. (New) A system for wireless data transmission, comprising:
a receiver having one or more receiving antennas utilizing information on received
interference signals to improve the quality of transmission of the data transmission, wherein
quantitative information is obtained about received user signals from the received signals
of one of the antennas by using a first signal processing algorithm, and
the quantitative information about the received interference signals is obtained from the
received signals of one of the antennas and the quantitative information obtained about the

received user signals by using a second signal processing algorithm wherein the quantitative information about the received interference signals is used for generating a directional pattern at the transmitter; and

a transmitter to generate a directional pattern based on the quantitative information about the received interference signals.

In the Abstract:

Please replace the Abstract in its entirety with the Abstract attached hereto.

Key to figure

- 1——Channel estimator
- 2——Common detector for the subscriber signals
- 3——FEC decoder
- 4——FEC coder
- 5——Signal reconstructor
- 6——Estimator for R_n

METHOD FOR OBTAINING INFORMATION ABOUT INTERFERENCE IN THE RECEIVER OF A MESSAGE TRANSMISSION SYSTEM

Abstract

A system and device for wireless data transmission where information about interference in a message transmission system is obtained in a receiver.

1/PR75

09/889518
JC18 Rec'd PCT/PTO 1 8 JUL 2001
PCT/DE00/00005

WO 00/44111

Description

Method for obtaining information about interference in the receiver of a message transmission system

5

The invention relates to a method and a device for wireless data transmission comprising one or more transmitters and at least one receiver, where information about interference in a message transmission system is obtained in the receiver.

10

In message or data transmission, it is desirable to obtain as uncorrupted a transmission of the user signals as possible, to suppress interference, which exists at the same time and in the same frequency band in addition to the wanted signal, and thermal noise, respectively, as well as possible in the receivers. To be able to selectively take measures against interference, it is required to know as much as possible about the characteristics of the interference.

15

Apart from the intensity of the interference, such characteristics are, for example, also its spectrum, its correlation properties and the directions of incidence of the interfering signals at the receiver.

20

In many cases such as, for example, in permanently installed radio transmission links, potential interfering influences by other permanently installed transmitters which do not emit any user signals from the point of view of the transmission link under consideration, are known a priori. According to the prior art, such interfering influences can be suppressed by simple measures such as directional transmission and reception; a procedure normally used in microwave radio. In many cases, especially in the multi-subscriber systems of mobile communication, such information on the properties of the interference is not known a priori. Accordingly, countermeasures adapted to the interference cannot be easily taken. Assuming interference-limited multi-subscriber systems

25

30

35

in which, therefore, the interference is essentially caused by other users of

1871
 1872
 1873
 1874
 1875
 1876
 1877
 1878
 1879
 1880
 1881
 1882
 1883
 1884
 1885
 1886
 1887
 1888
 1889
 1890
 1891
 1892
 1893
 1894
 1895
 1896
 1897
 1898
 1899
 1900
 1901
 1902
 1903
 1904
 1905
 1906
 1907
 1908
 1909
 1910
 1911
 1912
 1913
 1914
 1915
 1916
 1917
 1918
 1919
 1920
 1921
 1922
 1923
 1924
 1925
 1926
 1927
 1928
 1929
 1930
 1931
 1932
 1933
 1934
 1935
 1936
 1937
 1938
 1939
 1940
 1941
 1942
 1943
 1944
 1945
 1946
 1947
 1948
 1949
 1950
 1951
 1952
 1953
 1954
 1955
 1956
 1957
 1958
 1959
 1960
 1961
 1962
 1963
 1964
 1965
 1966
 1967
 1968
 1969
 1970
 1971
 1972
 1973
 1974
 1975
 1976
 1977
 1978
 1979
 1980
 1981
 1982
 1983
 1984
 1985
 1986
 1987
 1988
 1989
 1990
 1991
 1992
 1993
 1994
 1995
 1996
 1997
 1998
 1999
 2000
 2001
 2002
 2003
 2004
 2005
 2006
 2007
 2008
 2009
 2010
 2011
 2012
 2013
 2014
 2015
 2016
 2017
 2018
 2019
 2020
 2021
 2022
 2023
 2024
 2025
 2026
 2027
 2028
 2029
 2030
 2031
 2032
 2033
 2034
 2035
 2036
 2037
 2038
 2039
 2040
 2041
 2042
 2043
 2044
 2045
 2046
 2047
 2048
 2049
 2050
 2051
 2052
 2053
 2054
 2055
 2056
 2057
 2058
 2059
 2060
 2061
 2062
 2063
 2064
 2065
 2066
 2067
 2068
 2069
 2070
 2071
 2072
 2073
 2074
 2075
 2076
 2077
 2078
 2079
 2080
 2081
 2082
 2083
 2084
 2085
 2086
 2087
 2088
 2089
 2090
 2091
 2092
 2093
 2094
 2095
 2096
 2097
 2098
 2099
 2100
 2101
 2102
 2103
 2104
 2105
 2106
 2107
 2108
 2109
 2110
 2111
 2112
 2113
 2114
 2115
 2116
 2117
 2118
 2119
 2120
 2121
 2122
 2123
 2124
 2125
 2126
 2127
 2128
 2129
 2130
 2131
 2132
 2133
 2134
 2135
 2136
 2137
 2138
 2139
 2140
 2141
 2142
 2143
 2144
 2145
 2146
 2147
 2148
 2149
 2150
 2151
 2152
 2153
 2154
 2155
 2156
 2157
 2158
 2159
 2160
 2161
 2162
 2163
 2164
 2165
 2166
 2167
 2168
 2169
 2170
 2171
 2172
 2173
 2174
 2175
 2176
 2177
 2178
 2179
 2180
 2181
 2182
 2183
 2184
 2185
 2186
 2187
 2188
 2189
 2190
 2191
 2192
 2193
 2194
 2195
 2196
 2197
 2198
 2199
 2200
 2201
 2202
 2203
 2204
 2205
 2206
 2207
 2208
 2209
 2210
 2211
 2212
 2213
 2214
 2215
 2216
 2217
 2218
 2219
 2220
 2221
 2222
 2223
 2224
 2225
 2226
 2227
 2228
 2229
 2230
 2231
 2232
 2233
 2234
 2235
 2236
 2237
 2238
 2239
 2240
 2241
 2242
 2243
 2244
 2245
 2246
 2247
 2248
 2249
 2250
 2251
 2252
 2253
 2254
 2255
 2256
 2257
 2258
 2259
 2260
 2261
 2262
 2263
 2264
 2265
 2266
 2267
 2268
 2269
 2270
 2271
 2272
 2273
 2274
 2275
 2276
 2277
 2278
 2279
 2280
 2281
 2282
 2283
 2284
 2285
 2286
 2287
 2288
 2289
 2290
 2291
 2292
 2293
 2294
 2295
 2296
 2297
 2298
 2299
 2300
 2301
 2302
 2303
 2304
 2305
 2306
 2307
 2308
 2309
 2310
 2311
 2312
 2313
 2314
 2315
 2316
 2317
 2318
 2319
 2320
 2321
 2322
 2323
 2324
 2325

one's own system, the time correlation of the interfering signals is equal to the time correlation of the wanted signals and is thus known as long as interfering signals which are incident from different
5 directions are uncorrelated. Knowledge of the time correlation of the interfering signals can be utilized in the receiver for improving the transmission quality by decorrelating the interference.

TD-CDMA [1], as an example for third-generation
10 mobile radio systems, uses the hybrid FDMA/TDMA/CDMA (frequency/time/code division multiple access) method. The time correlation of the interfering signals can be taken into consideration in the data detection. An example in which no information about the correlation
15 properties of the interference are utilized is the WCDMA (wideband CDMA) [2, 3] air interface concept which is also proposed for third-generation mobile radio systems and which is based on the hybrid FDMA/CDMA multiple access method.

20 The disadvantageous factor in the transmission methods corresponding to the prior art is that they do not obtain information on the received interference, or only to a very limited extent, and thus do not use such information to a desirable degree for improving the
25 transmission quality. For example, no directional information at all is obtained with respect to the interference. If multiple-antenna receivers are used, directional patterns could be generated, for example when using array antennas, which selectively have less
30 gain for those directions from which strong interfering signals arrive at the receiver so that the ratio between useful power and interference power at the receiver end is maximized. However, this would require knowledge of the directions of interference which
35 cannot be obtained in the systems according to the prior art.

The considerations described above of the time correlations of the interference, assumed to be known a priori, for example in the case of TD-CDMA, too, are not about obtaining information about the interference.

5 Using a priori knowledge about the interference is questionable, especially in mobile communication, since the instantaneous characteristics of the interference can greatly deviate from those assumed a priori due to the permanent changing in time of the spatial
10 constellation of the mobile stations which, as a rule, is not predictable.

The prerequisite of uncorrelated interference signals arriving at the receiver from different directions, which has been addressed above, is also not
15 generally met. If the signal of an interference source propagates toward the receiver along a number of paths with different delay and/or if the interfering signals coming from one interference source have different directions of incidence at the location of the
20 receiver, the aggregate interference signal produced by superposition of the interference signals at the receiving location have different time correlations than the individual interference signals and thus also different time correlations than those of the user
25 signal which have been assumed a priori.

The problem of procuring information on the characteristics is solved by the method according to the invention in the manner shown in claim 1, where Ka receiving antennas are assumed. In this method,
30 information on the user signal is first obtained from the received signals of the antennas in a first step. From the total received signals which contain both the user signal(s) and the interference signal(s), and the information, obtained in the first step, about the user
35 signal(s), information about the interference signal(s) can then be obtained in a second step.

According to the embodiment of the method according to the invention as claimed in subclaims 2, 4 and 5, the information about the

[illegible]

interference signals is obtained, for example, by an approximate reconstruction of the received user signals and by subsequent subtraction of the reconstructed user signals from the total of the received signals. This embodiment thus provides an estimate of the time functions $\hat{n}^{(ka)}(t)$, $ka=1..Ka$ of the interference at the Ka receiving antennas.

Further advantageous embodiments of the method according to the invention are described in subclaims 8, 9 and 10. Using the estimates $\hat{n}^{(ka)}(t)$ determined as above, the estimates

$$\hat{R}_n^{(l,m)}(\tau) = E\{\hat{n}^{(l)}(t) \cdot (t+\tau)\} \quad l, m = 1..Ka \quad (1)$$

of the temporal covariance functions of the interference signals effective at the antennas can be obtained. In addition, the normalized spatial covariance matrix

$$\hat{R}_s = \frac{1}{\sigma^2} \begin{pmatrix} E\{\hat{n}^{(1)}(t) \cdot \hat{n}^{(1)*}(t)\} & E\{\hat{n}^{(1)}(t) \cdot \hat{n}^{(Ka)*}(t)\} \\ E\{\hat{n}^{(2)}(t) \cdot \hat{n}^{(1)*}(t)\} & E\{\hat{n}^{(2)}(t) \cdot \hat{n}^{(Ka)*}(t)\} \\ E\{\hat{n}^{(Ka)}(t) \cdot \hat{n}^{(1)*}(t)\} & E\{\hat{n}^{(Ka)}(t) \cdot \hat{n}^{(Ka)*}(t)\} \end{pmatrix} \quad (2)$$

of dimension $Ka \times Ka$ can be determined for the Ka receiving antennas, taking into consideration the interference power σ^2 , which can also be determined from the estimated interference signals. In the case of both the data transmission and digital signal processing at the receiving end, discrete-time samples are available as signals which can be subdivided into finite blocks due to their burst structure. If the subscriber signals are detected burst by burst, it is sufficient to determine information about the interference burst by burst. Accordingly, the interference signals at the individual antennas,

estimated in accordance with the embodiments of the method according to the invention according to subclaims 2, 4 and 5, can be represented as vectors

1870-1871. 1872-1873. 1874-1875. 1876-1877. 1878-1879. 1880-1881. 1882-1883. 1884-1885. 1886-1887. 1888-1889. 1890-1891. 1892-1893. 1894-1895. 1896-1897. 1898-1899. 1900-1901. 1902-1903. 1904-1905. 1906-1907. 1908-1909. 1910-1911. 1912-1913. 1914-1915. 1916-1917. 1918-1919. 1920-1921. 1922-1923. 1924-1925. 1926-1927. 1928-1929. 1930-1931. 1932-1933. 1934-1935. 1936-1937. 1938-1939. 1940-1941. 1942-1943. 1944-1945. 1946-1947. 1948-1949. 1950-1951. 1952-1953. 1954-1955. 1956-1957. 1958-1959. 1960-1961. 1962-1963. 1964-1965. 1966-1967. 1968-1969. 1970-1971. 1972-1973. 1974-1975. 1976-1977. 1978-1979. 1980-1981. 1982-1983. 1984-1985. 1986-1987. 1988-1989. 1990-1991. 1992-1993. 1994-1995. 1996-1997. 1998-1999. 2000-2001. 2002-2003. 2004-2005. 2006-2007. 2008-2009. 2010-2011. 2012-2013. 2014-2015. 2016-2017. 2018-2019. 2020-2021. 2022-2023. 2024-2025. 2026-2027. 2028-2029. 2030-2031. 2032-2033. 2034-2035. 2036-2037. 2038-2039. 2040-2041. 2042-2043. 2044-2045. 2046-2047. 2048-2049. 2050-2051. 2052-2053. 2054-2055. 2056-2057. 2058-2059. 2060-2061. 2062-2063. 2064-2065. 2066-2067. 2068-2069. 2070-2071. 2072-2073. 2074-2075. 2076-2077. 2078-2079. 2080-2081. 2082-2083. 2084-2085. 2086-2087. 2088-2089. 2090-2091. 2092-2093. 2094-2095. 2096-2097. 2098-2099. 2100-2101. 2102-2103. 2104-2105. 2106-2107. 2108-2109. 2110-2111. 2112-2113. 2114-2115. 2116-2117. 2118-2119. 2120-2121. 2122-2123. 2124-2125. 2126-2127. 2128-2129. 2130-2131. 2132-2133. 2134-2135. 2136-2137. 2138-2139. 2140-2141. 2142-2143. 2144-2145. 2146-2147. 2148-2149. 2150-2151. 2152-2153. 2154-2155. 2156-2157. 2158-2159. 2160-2161. 2162-2163. 2164-2165. 2166-2167. 2168-2169. 2170-2171. 2172-2173. 2174-2175. 2176-2177. 2178-2179. 2180-2181. 2182-2183. 2184-2185. 2186-2187. 2188-2189. 2190-2191. 2192-2193. 2194-2195. 2196-2197. 2198-2199. 2200-2201. 2202-2203. 2204-2205. 2206-2207. 2208-2209. 2210-2211. 2212-2213. 2214-2215. 2216-2217. 2218-2219. 2220-2221. 2222-2223. 2224-2225. 2226-2227. 2228-2229. 2230-2231. 2232-2233. 2234-2235. 2236-2237. 2238-2239. 2240-2241. 2242-2243. 2244-2245. 2246-2247. 2248-2249. 2250-2251. 2252-2253. 2254-2255. 2256-2257. 2258-2259. 2260-2261. 2262-2263. 2264-2265. 2266-2267. 2268-2269. 2270-2271. 2272-2273. 2274-2275. 2276-2277. 2278-2279. 2280-2281. 2282-2283. 2284-2285. 2286-2287. 2288-2289. 2290-2291. 2292-2293. 2294-2295. 2296-2297. 2298-2299. 2300-2301. 2302-2303. 2304-2305. 2306-2307. 2308-2309. 2310-2311. 2312-2313. 2314-2315. 2316-2317. 2318-2319. 2320-2321. 2322-2323. 2324-2325. 2326-2327. 2328-2329. 2330-2331. 2332-2333. 2334-2335. 2336-2337. 2338-2339. 2340-2341. 2342-2343. 2344-2345. 2346-2347. 2348-2349. 2350-2351. 2352-2353. 2354-2355. 2356-2357. 2358-2359. 2360-2361. 2362-2363. 2364-2365. 2366-2367. 2368-2369. 2370-2371. 2372-2373. 2374-2375. 2376-2377. 2378-2379. 2380-2381. 2382-2383. 2384-2385. 2386-2387. 2388-2389. 2390-2391. 2392-2393. 2394-2395. 2396-2397. 2398-2399. 2400-2401. 2402-2403. 2404-2405. 2406-2407. 2408-2409. 2410-2411. 2412-2413. 2414-2415. 2416-2417. 2418-2419. 2420-2421. 2422-2423. 2424-2425. 2426-2427. 2428-2429. 2430-2431. 2432-2433. 2434-2435. 2436-2437. 2438-2439. 2440-2441. 2442-2443. 2444-2445. 2446-2447. 2448-2449. 2450-2451. 2452-2453. 2454-2455. 2456-2457. 2458-2459. 2460-2461. 2462-2463. 2464-2465. 2466-2467. 2468-2469. 2470-2471. 2472-2473. 2474-2475. 2476-2477. 2478-2479. 2480-2481. 2482-2483. 2484-2485. 2486-2487. 2488-2489. 2490-2491. 2492-2493. 2494-2495. 2496-2497. 2498-2499. 2500-2501. 2502-2503. 2504-2505. 2506-2507. 2508-2509. 2510-2511. 2512-2513. 2514-2515. 2516-2517. 2518-2519. 2520-2521. 2522-2523. 2524-2525. 2526-2527. 2528-2529. 2530-2531. 2532-2533. 2534-2535. 2536-2537. 2538-2539. 2540-2541. 2542-2543. 2544-2545. 2546-2547. 2548-2549. 2550-2551. 2552-2553. 2554-2555. 2556-2557. 2558-2559. 2560-2561. 2562-2563. 2564-2565. 2566-2567. 2568-2569. 2570-2571. 2572-2573. 2574-2575. 2576-2577. 2578-2579. 2580-2581. 2582-2583. 2584-2585. 2586-2587. 2588-2589. 2590-2591. 2592-2593. 2594-2595. 2596-2597. 2598-2599. 2600-2601. 2602-2603. 2604-2605. 2606-2607. 2608-2609. 2610-2611. 2612-2613.

$$\hat{\underline{n}}^{(ka)} = (\hat{n}_1, \hat{n}_2, \dots, \hat{n}_{WB})^T, ka = 1..Ka \quad (3)$$

where \hat{n}_i , $i=1..WB$, are the WB samples of the interference signal over one burst, since these interference signals are time-discrete and limited in time. The embodiment of the method according to the invention according to subclaims 8, 9 and 10 thus leads to finite, discrete-time covariance functions.

Instead of forming the expected value when determining the covariance functions, which requires infinite averaging over the estimated samples of the interference, the temporal averaging must be finite in real systems. It is performed over a previously defined number Z of bursts. In the case of a mobile radio system, Z depends on the rate of change of the constellation of mobile stations. If the constellation of mobile stations changes greatly from burst to burst, Z must be selected to be equal to one. If not, Z can be greater than 1. If the Z vectors according to (3) at the Ka antennas according to

$$\hat{\underline{N}}_t^{(ka)} = (\hat{n}_1^{Ka}, \hat{n}_2^{Ka}, \dots, \hat{n}_Z^{Ka})^T, ka = 1..Ka \quad (4)$$

are ordered into in each case WB x Z matrices, estimates

$$\hat{\underline{R}}_n^{(l,m)} = \frac{1}{Z} \cdot \hat{\underline{N}}_t^{(l)} \cdot \hat{\underline{N}}_t^{(m)*T}, \quad l, m = 1..Ka \quad (5)$$

of the temporal covariance matrices can be formed in derivation of (1). The following then holds for the estimate of the total covariance matrices:

$$\hat{\underline{R}}_n = \begin{pmatrix} \hat{\underline{R}}_n^{(1,1)} & \hat{\underline{R}}_n^{(1,2)} & \dots & \hat{\underline{R}}_n^{(1,Ka)} \\ \hat{\underline{R}}_n^{(2,1)} & \hat{\underline{R}}_n^{(2,2)} & \dots & \hat{\underline{R}}_n^{(2,Ka)} \\ \vdots & \vdots & \ddots & \vdots \\ \hat{\underline{R}}_n^{(Ka,1)} & \hat{\underline{R}}_n^{(Ka,2)} & \dots & \hat{\underline{R}}_n^{(Ka,Ka)} \end{pmatrix} \quad (6)$$

The actual interference vectors $\underline{n}^{(ka)}(t)$,
 $ka=1..Ka$, at the Ka antennas can be correlated with the
 estimated interference vectors $\hat{\underline{n}}^{(ka)}(t)$, $ka=1..Ka$,
 according to (3) and combined in a total interference
 5 vector

$$\underline{n}^{(ka)} = \left(\underline{n}^{(1)T}, \underline{n}^{(2)T} \dots \underline{n}^{(Ka)T} \right)^T \quad (7)$$

The actual total covariance matrix of the interference
 10 is as obtained as

$$\underline{R}_n = E \{ \underline{n} \underline{n}^{*T} \} \quad (8)$$

Assuming uncorrelated interference signals
 15 arriving at the receiving site from various directions,
 the actual total covariance matrix \underline{R}_n according to (8)
 can be split into a spatial covariance matrix \underline{R}_s and a
 temporal covariance matrix \underline{R}_t which is equal for all
 received signals at the Ka receiving antennas, so that
 20 the following holds true:

$$\underline{R}_n = \underline{R}_s \otimes \underline{R}_t. \quad (9)$$

If it is only intended to obtain an estimate $\hat{\underline{R}}_s$,
 25 of the spatial covariance matrix, the $Ka \times Z$ WB matrix
 is used as a basis

$$\hat{\underline{N}}_s = \begin{pmatrix} \hat{\underline{n}}_1^{(1)T} & \hat{\underline{n}}_2^{(1)T} & \dots & \hat{\underline{n}}_Z^{(1)T} \\ \dots & \dots & \dots & \dots \\ \hat{\underline{n}}_1^{(Ka)T} & \hat{\underline{n}}_2^{(Ka)T} & \dots & \hat{\underline{n}}_Z^{(Ka)T} \end{pmatrix} \quad (10)$$

30 and the required estimate $\hat{\underline{R}}_s$ is determined according to

$$\hat{\underline{R}}_s = \frac{1}{Z \cdot WB} \cdot \hat{\underline{N}}_s \cdot \hat{\underline{N}}_s^{*T} \quad (11)$$

that, instead of possibly faulty a priori information about the interference to be expected, the information about the interference is obtained from the actual received signal and is thus continuously updated. A

44111-6a-00005

An important advantage, which can be achieved with the method according to the invention, lies in

11/20/2000 12:45:43 PM

further advantage lies in the possibility of obtaining information both on the spatial correlation characteristics of the interference and on the temporal correlation characteristics of the interference.

5 This information can be used either directly to suppress interference when estimating the user signals from the received signals, or information about the directions of incidence of the interference at the receiver can be obtained from the information about the
10 spatial correlation characteristics of the interference, depending on the signal processing algorithm. In the case of multi-antenna receivers, the information about the directions of incidence of the interference at the receiver or, respectively, about
15 the spatial correlation characteristics of the interference can be used for generating directional patterns which selectively have less gain in those directions from which strong interference signals arrive at the receiver so that the ratio between useful
20 power and interference power at the receiver end is maximized.

 The previous considerations relate to the receiver end. In duplex systems, each receiver is paired with a transmitter. If multi-antenna systems are
25 used for receiving and transmitting, the information about the received interference, obtained in accordance with the method explained above, can be used for advantageously driving the antennas in the transmitting case. The basic idea of this is that sending one's own
30 signals into the directions from which strong interference signals are incident tends to produce strong interference in other receivers. When a number of antennas is used, therefore, the knowledge of the main directions of interference at the receiver end can
35 be generally used, independently of the transmission system considered, to radiate as little power of the transmitted signal as possible in the directions of the

main interference source and thus to reduce interference seen throughout the system.

202200 21560000

of the uplink of a TD-CDMA mobile radio system in the text which follows. Moreover, it is shown here how the information obtained can be used for improving the quality of transmission. Use in other transmission systems is also included in the scope of the invention.

The corresponding receiving system is shown in figure 1. It is assumed that K mobile subscribers are simultaneously transmitting in the same frequency band and time slot and the subscriber signals are separated by subscriber-specific CDMA codes.

The transmitted bursts consist of two data blocks and a midamble arranged between them which provides for the channel estimate at the receiver end. In the text which follows, only the first data block of a burst will be considered in the description of the data detection. A corresponding observation would apply to the second data block. According to [4], a system matrix \underline{A} can be set up which includes both the $K * K_a$ channel impulse responses of the K subscribers to the K_a receiving antennas and the type of signal generation at the transmitter end. Together with the total data vector \underline{d} , which contains the data blocks of the K subscribers, and a total interference vector \underline{n} , the total received-signal vector \underline{e}

25

$$\underline{e} = \underline{A}\underline{d} + \underline{n} \quad (12)$$

is obtained. \underline{e} contains all samples of the received signals at all K_a antennas which are based on the first data block of a transmitted burst. Firstly, a channel estimator 1 forms a channel estimate in a first step and a common detector 2 performs joint detection of the subscriber signals [4] by means of the generally disturbed received signals \underline{e} . In TD-CDMA systems, algorithms which can include the knowledge of the entire covariance matrix according to (8) are used for the joint data estimate of all subscribers.

35

One example of such algorithms is the zero-forcing algorithm. In one- or multi-antenna receivers in systems according to the prior art, it is assumed that the temporal covariance matrix \underline{R}_t can be
 5 determined directly from the spectral shape of the transmitted signals. In the text which follows, this covariance matrix is designated by \underline{R}_t . This matrix \underline{R}_t is taken into consideration in the data detection even though the actual temporal correlations of the
 10 interference signals at the receiving site may deviate from the assumed temporal correlations due to multi-path propagation of the interference from an interference source.

In the case of multi-antenna receivers in
 15 systems according to the prior art, the spatial correlations of the interference are not taken into consideration in the detection of the data and/or in the channel estimate, i.e. the covariance matrix \underline{R}_s is replaced by the $K_a \times K_a$ unity matrix $I^{(K_a)}$. Thus there
 20 is no optimum data detection in the sense of the zero-forcing algorithm in systems according to the prior art. The method according to the invention can be used for improving the data estimate and the channel estimate by prior estimating of the covariance matrix
 25 \underline{R}_n of the interference due to the estimating of the received interference at each antenna, see figure 1.

To estimate the interference, a conventional data detection is first performed for a more or less large number of received bursts, using the matrix

30

$$\underline{R}_n = I^{(K_a)} \otimes \tilde{\underline{R}}, \quad (13)$$

for the covariance matrix \underline{R}_n according to (8), using the matrix $\tilde{\underline{R}}$. This provides an estimate

35

$$\hat{\underline{d}} = \left(\hat{\underline{A}}^* \underline{R}_n^{-1} \hat{\underline{A}} \right)^{-1} \hat{\underline{A}}^* \underline{R}_n^{-1} \underline{e} \quad (14)$$

of the transmitted data which can be used for the approximate reconstruction of the received signal based on the user signals

$$\underline{\hat{e}}_d = \underline{\hat{A}} \cdot \underline{\hat{d}} \quad (15)$$

by means of the system matrix $\underline{\hat{A}}$ which includes the information about the estimated $K * K_a$ channel impulse responses. The reconstruction $\underline{\hat{e}}_d$ is performed in a signal reconstructor 5. Units 3 and 4 (FEC decoder and FEC coder) can be arranged between units 2 and 5. Unit 3 performs FEC decoding at the receiver end for the case in which FEC coding is taken into consideration in the signal processing at the transmitter end. In unit 4, a corresponding FEC coding of the estimated data must then taken place to obtain correct signal reconstruction. Subtracting the reconstructed received signal $\underline{\hat{e}}_d$ according to (15) from the actual received signal \underline{e} according to (12) makes it possible to determine an estimate

$$\underline{\hat{n}} = \underline{e} - \underline{\hat{e}}_d \quad (16)$$

for the total interference factor \underline{n} according to (7). From the estimates of the interference signals at the individual antennas, which were thus obtained, both the spatial correlation characteristics of the interference, see (11), and the temporal correlation characteristics of the interference, see (5), and thus the covariance matrix $\underline{\hat{R}}_n$ of the interference according to (6) can be estimated in an estimating unit 6.

Taking into consideration the estimated covariance matrix, the signals received at the individual antennas can be subjected both to an improved channel estimate, if such a one is required, and to an improved data estimate, in a second step, \underline{R}_n according to (13) being replaced by $\underline{\hat{R}}_n$.

The procedure described up to here can be iteratively continued. Assuming that the interference scenario, and thus also the correlation characteristics of the interference, do not or not significantly change during the provided period of estimating the matrix and in the subsequent period which is provided for estimating new data, the estimated covariance matrix \hat{R}_n can be used for estimating new data in order to achieve an improvement in the data estimate already in the first step.

References

- [1] A. Klein, P.W. Baier: Linear unbiased data
estimation in mobile radio systems applying CDMA. IEEE
5 Journal on Selected Areas in Communications, Vol. 11,
1993, p. 1058 to 1066
- [2] F. Adachi, K. Ohno, A. Higashi, T. Dohi,
Y. Okumura: Coherent multicode DS-CDMA mobile radio
10 access DS-CDMA mobile radio system, IEICE Transactions
on Communications, Vol. E79-B, No. 9, 1996, p. 1316 to
1324
- [3] F. Adachi, M. Sawahashi: Wideband multi-rate
15 DS-CDMA for next generation mobile communications
systems. Proc. IEEE Wireless Communications Conference
(WCC'97), Boulder, 1997, p. 57 to 62
- [4] R. Schmalenberger, J.J. Blanz: Multi antenna C/I
20 balancing in the downlink of digital cellular mobile
radio systems. Proc. IEEE Vehicular Technology
Conference (VTC'97), Phoenix, 1997, p. 607 to 611

Patent claims

1. A method for the wireless data transmission using one or more transmitters and at least one
5 receiver, in which
- the receiver uses one or more receiving antennas,
 - information on received interference signals is utilized for improving the quality of transmission of the data transmission,
 - 10 - in a first step, quantitative information about received user signals is obtained from the received signals of the individual antennas by using first signal processing algorithms,
 - and in a second step, quantitative information
15 about the received interference signals is obtained from the received signals of the antenna or the individual antennas and the quantitative information obtained about the received user signals by using second signal processing
20 algorithms,
- characterized in that the quantitative information about the received interference signals is used for generating a directional pattern at the transmitter end.
- 25 2. The method as claimed in claim 1, characterized in that the first signal processing algorithms provide for an estimate of the transmitted user data.
3. The method as claimed in claim 1, characterized in that the first signal processing algorithms provide
30 for an estimate of the characteristics of the radio channels operating between the transmitters and the receiver.
4. The method as claimed in one of the preceding claims, characterized in that

AMENDED SHEET

dc-270651

the second signal processing algorithms contain algorithms for reconstructing the user signals received from the receiving antenna/the receiving antennas by means of the quantitative information obtained about these signals.

5 The method as claimed in claim 1 or 3, characterized in that the second signal processing algorithms contained a weighted or unweighted subtraction of the reconstructed received user signals from the total received signals.

10 The method as claimed in one of the preceding claims, characterized in that the second signal processing algorithms contain the forming of the spatial covariance matrix of the received interference signals.

15 The method as claimed in one of the preceding claims, characterized in that the second signal processing algorithms contain the forming of the temporal covariance functions of the received interference signals at the individual antennas.

20 The method as claimed in one of the preceding claims, characterized in that the second signal processing algorithms contain the forming of the total covariance functions of the received interference signals.

25 The method as claimed in one of the preceding claims, characterized in that the second signal processing algorithms contain the estimating of the spatial, temporal and/or total covariance functions by finite temporal averaging over the received interference signals.

30 The method as claimed in one of the preceding claims,

AMENDED SHEET

characterized in that the second signal processing algorithms contain the estimating of the directions of incidence of the interference.

11. The method as claimed in one of the preceding
5 claims, characterized in that the second signal processing algorithms contain the estimating of the power and/or the spectral shape of the interference.

12. The method as claimed in one of the preceding
10 claims, characterized in that the first signal processing algorithms contain the forming of the spatial covariance matrix of the received user signals.

13. The method as claimed in one of the preceding
15 claims, characterized in that the first signal processing algorithms are based on the principle of single user detection in the case of data transmission.

14. The method as claimed in one of the preceding
claims, characterized in that the first signal processing algorithms are based on the principle of multi-user detection in the case of data transmission.

15. The method as claimed in one of the preceding
20 claims, characterized in that the first signal processing algorithms are based on the principle of the rake receiver in the case of data transmission.

16. The method as claimed in one of the preceding
25 claims, characterized in that the first signal processing algorithms include FEC (forward error correction) decoding at the receiver end in the case of data transmission.

AMENDED SHEET

17. The method as claimed in one of the preceding claims, characterized in that the first signal processing algorithms are based on the principle of the zero-forcing algorithm.

5 18. The method as claimed in one of the preceding claims, characterized in that the first signal processing algorithms are based on the principle of maximum-likelihood estimation or MMSE (minimum mean square error) estimation.

10 19. An arrangement for carrying out the method as claimed in claim 1.

AMENDED SHEET

dc-270651

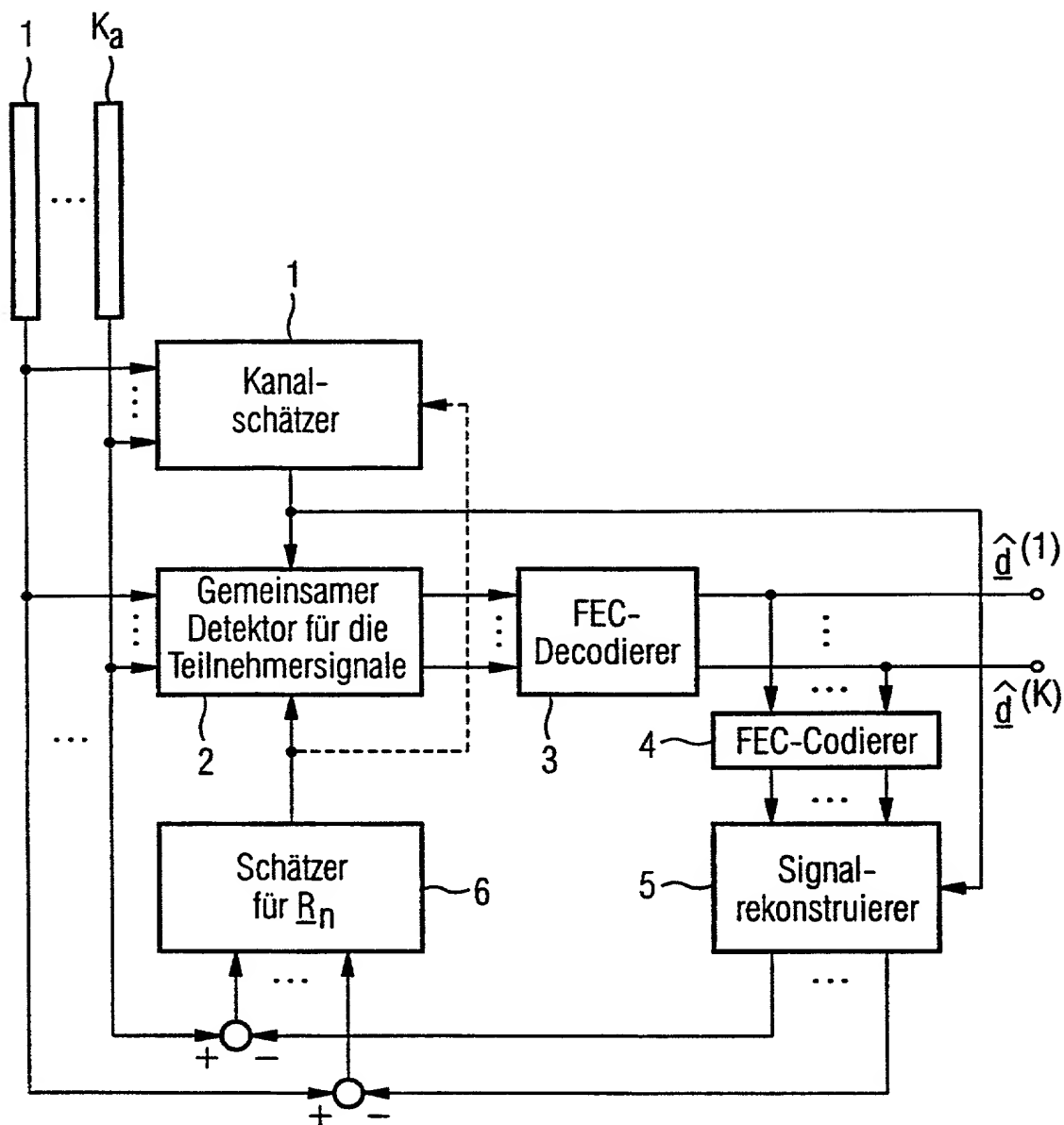
070303 10 002704
T 02200 0750050

Key to figure

- 1 Channel estimator
- 5 2 Common detector for the subscriber signals
- 3 FEC decoder
- 4 FEC coder
- 5 Signal reconstructor
- 6 Estimator for R_n

T 0 2 2 0 0 7 5 6 3 6 3

1/1



Declaration and Power of Attorney For Patent Application

Erklärung Für Patentanmeldungen Mit Vollmacht

German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

dass ich, nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent beantragt wird für die Erfindung mit dem Titel:

Verfahren zum Gewinnen von
Informationen ueber Stoerungen im
Empfaenger eines
Nachrichtenuebertragungssystems

deren Beschreibung

(zutreffendes ankreuzen)

☐ hier beigefügt ist.

☒ am 03.01.2000 als

PCT internationale Anmeldung

PCT Anwendungsnummer PCT/DE00/00005

eingereicht wurde und am _____

abgeändert wurde (falls tatsächlich abgeändert).

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Method for obtaining information
regarding interference in the receiver of a
message transmission system

the specification of which

(check one)

☐ is attached hereto.

☒ was filed on 03.01.2000 as

PCT international application

PCT Application No. PCT/DE00/00005

and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

German Language Declaration

Prior foreign applications
Priorität beansprucht

Priority Claimed

19901877.4

DE

19.01.1999

☒

☐

(Number)
(Nummer)

(Country)
(Land)

(Day Month Year Filed)
(Tag Monat Jahr eingereicht)

Yes
Ja

No
Nein

(Number)
(Nummer)

(Country)
(Land)

(Day Month Year Filed)
(Tag Monat Jahr eingereicht)

☐
Yes
Ja

☐
No
Nein

(Number)
(Nummer)

(Country)
(Land)

(Day Month Year Filed)
(Tag Monat Jahr eingereicht)

☐
Yes
Ja

☐
No
Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §122, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

PCT/DE00/00005

(Application Serial No.)
(Anmeldeseriennummer)

03.01.2000

(Filing Date D, M, Y)
(Anmeldedatum T, M, J)

anhängig

(Status)
(patentiert, anhängig,
aufgegeben)

pending

(Status)
(patented, pending,
abandoned)

(Application Serial No.)
(Anmeldeseriennummer)

(Filing Date D,M,Y)
(Anmeldedatum T, M; J)

(Status)
(patentiert, anhängig,
aufgeben)

(Status)
(patented, pending,
abandoned)

Ich erkläre hiermit, dass alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und dass ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, dass wissentlich und vorsätzlich falsche Angaben gemäss Paragraph 1001, Absatz 18 der Zivilprozessordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden koennen, und dass derartig wissentlich und vorsätzlich falsche Angaben die Gültigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentes gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

German Language Declaration

VERTRETUNGSVOLLMACHT: Als benannter Erfinder beauftrage ich hiermit den nachstehend benannten Patentanwalt (oder die nachstehend benannten Patentanwälte) und/oder Patent-Agenten mit der Verfolgung der vorliegenden Patentanmeldung sowie mit der Abwicklung aller damit verbundenen Geschäfte vor dem Patent- und Warenzeichenamt: (Name und Registrationsnummer anführen)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name and registration number)

Customer No. 25227

And I hereby appoint

Telefongespräche bitte richten an:
(Name und Telefonnummer)

Direct Telephone Calls to: (name and telephone number)

Ext. _____

Postanschrift:

Send Correspondence to:

Morrison and Foerster LLP
2000 Pennsylvania Ave., NW 20006-1888 Washington, DC
Telephone: (001) 202 887 1500 and Facsimile (001) 202 887 0763
or
Customer No. 25227

| | | | |
|--|---------|---|---------|
| Voller Name des einzigen oder ursprünglichen Erfinders: | | Full name of sole or first inventor: | |
| Prof. PAUL WALTER BAIER | | Prof. PAUL WALTER BAIER | |
| Unterschrift des Erfinders | Datum | Inventor's signature | Date |
| <i>Paul Walter Baier</i> | 12.7.01 | <i>Paul Walter Baier</i> | |
| Wohnsitz | | Residence | |
| KAISERSLAUTERN, DEUTSCHLAND | | KAISERSLAUTERN, GERMANY DEX | |
| Staatsangehörigkeit | | Citizenship | |
| DE | | DE | |
| Postanschrift | | Post Office Address | |
| BURGUNDER STR. 6 | | BURGUNDER STR. 6 | |
| 67661 KAISERSLAUTERN | | 67661 KAISERSLAUTERN | |
| Voller Name des zweiten Miterfinders (falls zutreffend): | | Full name of second joint inventor, if any: | |
| Dr. MARTIN HAARDT | | Dr. MARTIN HAARDT | |
| Unterschrift des Erfinders | Datum | Second inventor's signature | Date |
| <i>Martin Haardt</i> | 20.7.01 | <i>Martin Haardt</i> | 7/20/01 |
| Wohnsitz | | Residence | |
| MUENCHEN, DEUTSCHLAND | | MUENCHEN, GERMANY DEX | |
| Staatsangehörigkeit | | Citizenship | |
| DE | | DE | |
| Postanschrift | | Post Office Address | |
| WENGLEINSTR. 3 | | WENGLEINSTR. 3 | |
| 81477 MUENCHEN | | 81477 MUENCHEN | |

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

(Supply similar information and signature for third and subsequent joint inventors).

3-00

| | | | |
|---|------------------------|---|-----------------------|
| Voller Name des dritten Miterfinders: MARTIN WECKERLE | | Full name of third joint inventor: MARTIN WECKERLE | |
| Unterschrift des Erfinders <i>Martin Weckerle</i> | Datum 3.8.01 | Inventor's signature <i>Martin Weckerle</i> | Date 8/3/01 |
| Wohnsitz Neustadt KAISERSLAUTERN, DEUTSCHLAND | | Residence Neustadt KAISERSLAUTERN, GERMANY | |
| Staatsangehörigkeit DE | | Citizenship DEX | |
| Postanschrift Karlstr. 3 ALBERT-SCHWEITZER-STR.60 | | Post Office Address Karlstr. 3 ALBERT-SCHWEITZER-STR.60 | |
| 67655 KAISERSLAUTERN 67433 Neustadt | | 67655 KAISERSLAUTERN 67433 Neustadt | |
| Voller Name des vierten Miterfinders: | | Full name of fourth joint inventor: | |
| Unterschrift des Erfinders | Datum | Inventor's signature | Date |
| Wohnsitz | | Residence | |
| Staatsangehörigkeit | | Citizenship | |
| Postanschrift | | Post Office Address | |
| | | | |
| Voller Name des fünften Miterfinders: | | Full name of fifth joint inventor: | |
| Unterschrift des Erfinders | Datum | Inventor's signature | Date |
| Wohnsitz | | Residence | |
| Staatsangehörigkeit | | Citizenship | |
| Postanschrift | | Post Office Address | |
| | | | |
| Voller Name des sechsten Miterfinders: | | Full name of sixth joint inventor: | |
| Unterschrift des Erfinders | Datum | Inventor's signature | Date |
| Wohnsitz | | Residence | |
| Staatsangehörigkeit | | Citizenship | |
| Postanschrift | | Post Office Address | |
| | | | |

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

(Supply similar information and signature for third and subsequent joint inventors).